Development of an open spray model for the FLUENT framework

To overcome the limitations of the FLUENT built-in spray models, an open model structure has been developed that offers extended breakup and drag models, vaporization laws and collision models. For secondary breakup, the TAB and KH-model already integrated in FLUENT have been reimplemented. The open model structure allows applying both models simultaneously, i.e. the TAB models for low Weber number droplets and the KH model for high Weber number droplets. Aside from these standard models, additional models have been implemented, e.g. a very recent phenomenological model by Chryssakis and Assanis [1], and a mixed physical-phenomenological model by Reichelt [2]. All breakup models are implemented with their corresponding drag laws. The vaporization models are based on heat and mass transfer laws by Sirignano [3]. The collision models are based on O’Rourke- and NTC-algorithms [4,5] and account for all collision regimes (coalescence, stretching separation, reflexive separation and bouncing). Coupling between the models has been extended over the standard FLUENT models; e.g. the vaporization models account for drop deformation and the collision model directly influences secondary breakup. In this presentation, the focus is put on technical aspects of the model implementation.

Implementation of an Open Spray Model for the FLUENT Framework

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Advantages of an Open Model Structure

- Extensibility
- Open the Black-Box
- Smooth Model-Coupling

Sub-Models Implemented

- Primary and Secondary Breakup
- Collision and Coalescence
- Collision-Breakup-Coupling
- Phase-Coupling
- Vaporization
Secondary Breakup
Hybrid KH-TAB-Model

- KH Model for high Weber numbers (80 < We < 800)
- TAB Model for low Weber numbers (12 < We < 80)

Secondary Breakup
KH-Model Implementation

KH-Model Keeps Track of Mean Properties
Secondary Breakup
Hybrid KH-TAB-Model: Drop Size Validation

P. Pischke, D. Martin, R. Kneer, Combined Spray Model for GDI Hollow-Cone Sprays, AaS 20(4) 2010

Secondary Breakup
Unified Breakup Model

• One Secondary Breakup Model for all Engine Sprays
  (C. Chryssakis, D. Assanis)

P. Pilch, Erdmann (1987)
Collision and Coalescence Model

Introduction of a dedicated Collision Iteration

Gas-Phase Iteration

Droplet Iteration

Droplet Motion
Vaporization
Breakup
Collision

Collision Iteration

Search Schemes

Trade Performance for Accuracy
Collision and Coalescence Model
Search Scheme Artifacts

Collision and Coalescence Model
Search Radius Dependency

- Search Radius: 0.4 mm
- Search Radius: 1.0 mm

Graph showing accumulated collisions over time with different search radii.
Collision and Coalescence Model
Two- and Four-Regime Model

Impact Parameter (B)
Collision Weber Number
- stretching separation
- coalescence
- scattering
- bouncing
- reflexive separation

Modified Four-Regime Model

a) O'Rourke
b) Munnannur and Reitz
c) Munnannur and Reitz modified
d) Measurement

P. Piachka, D. Martin, R. Kneer, Combined Spray Model for GDI Hollow-Cone Sprays, AaS 20(4) 2010
Conclusions

- The models implemented have significantly improved the accuracy of the simulation
- Open model structures allow for in-depth investigations of all modelling aspects
- Fluent offers great extensibility by User Defined Functions (UDFs)
Thanks for Your Attention

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